

4. Discussion

The obtained results showed that the vegetative growth of rose plant was negatively affected by salinity treatments. The reduction of growth is a common indicator of salt stress because of inadequate water uptake (Borsani et al., 2003). The plant height, branch number, leaf and stem dry weights as well as leaf area were gradually decreased with increasing salinity levels. The vegetative growth reduction occurred as a result of salinity may be due to the reduction of both cell division and enlargement (Yasseen et al., 1987). Otherwise, inhibition of shoot growth has been considered a whole plant adaptation to salt stress (Qaderi et al. 2006). The suppression of growth under salt-stress may be also due to direct effects of ion toxicity especially Na and Cl or indirect effects of saline ions that cause soil/plant osmotic imbalance (Hajiboland et al., 2010). Caia et al. (2014) reported that under salt stress the uptake of water and some mineral nutrients were restricted and hence plant growth and development were inhibited, as well as a series of metabolic functions. These results support the others obtained by (Shoresh et al., 2011; Khalid and Cai, 2011).

Decreasing RWC in rose leaves as our data indicated may be a possible explanation for decreasing the growth parameters because it considers as an important parameter for water status. As a result of a reduction in water content under salt stress a loss of turgor was occurred and resulted in limited water availability for the cell extension process (Katerji et al., 1997). These results support the previous results obtained by Tuna et al. (2008) and Ali et al. (2012).

Increasing stomatal density by salinity may be occurred to make an adaptation to salt and inhabitation of its uptake. Stress has been found correlate with increased stomatal density (Clifford et al., 1995; Heckenberger et al., 1998; Pääkkönen et al., 1998). Salinity treatments also decreased the chlorophyll content of rose leaves. This decrease may be due to a reduction in the uptake of minerals i.e. Mg needed for chlorophyll biosynthesis (Sheng et al., 2008), membrane deterioration (Ashraf and Bhatti, 2000), or the suppression of specific enzymes that are responsible for the synthesis of photosynthetic pigments (Murkute et al., 2006). Our results support the first two reasons because we observed a significant decrease in Mg and increase in membrane permeability under salt stress. Decreasing total chlorophyll content of leaves by increasing salinity has been previously reported (Tuna et al., 2008; Shoresh et al., 2011; Celik and Atak, 2012).

A significant increase of total soluble sugars in salt stressed plants was observed. This increment may be occurred to regulate the osmotic potential under salinity treatments (Teixeira and Pereira, 2007) or to sustain metabolism, prolong energy supply and for better recovery after stress relieve (Slama et al., 2007). These results are in accordance with the others of Khalid and Cai (2011) who revealed that salinity stress increased the activity of sucrose phosphate synthase; the key enzyme in the sucrose synthesis pathway, consequently, the total soluble sugars was increased. The accumulation of compatible compounds (osmolytes) including proline is related to improvement of plant tolerance to salt because of its ability to overcome osmotic

and water stress and maintain nutrients homeostasis and ion compartmentalization (Nazar et al., 2011; Khan et al., 2012). Proline acts as a compatible osmolyte, enzyme protectant, free radical scavenger, cell redox balancer, cytosolic pH buffer and stabilizer for subcellular structures and therefore, it plays a protective function against salinity stress in plants (Verbruggen and Hermans, 2008). Such proline accumulation as a result of salt stress is well documented (Celik and Atak, 2012; Ashfaq et al., 2014).

The membrane permeability of rose leaves was significantly increased as a result of salinity application compared with the control. These results could be explained through the negative effects of salinity on Ca level since Ca is required to improve membrane stability (Shoresh et al., 2011). Our results show that the antioxidant enzymes activities (CA, SOD and POD) were increased by salt stress compared to the control. There is evidence that salt stress can induce oxidative stress due to generation of reactive oxygen species (ROS) (Gill and Tuteja, 2010). Under salinity stress which considers as an oxidative stress, plants produce (ROS), which are harmful to plant growth due to their detrimental effects on the sub cellular components and metabolism of the plant, leading to the oxidative destruction of cells and finally cause deterioration of membrane lipids, leading to increased leakage of solutes from membranes (Mishra and Choudhuri, 1999). As a result of ROS production, plant cell has to activate the antioxidant defense system including enzymatic antioxidant to scavenge ROS (Sairam et al. 2005). It has been reported that that high peroxidase activity is correlated with the reduction of plant growth and this increment may play an important role as defense against salt stress (Agarwal and Pandey, 2004). The increment in antioxidant enzyme activity under salt stress has been reported in several plants (Eraslan et al., 2007; Bernstein et al., 2010).

Applying salinity treatments decreased N, P, K, Ca and Mg contents however Na and Cl were increased. Decreasing N under salinity treatment has been previously reported (Nazar et al., 2011; Tarighaleslami et al., 2012). Moreover, reduction of P uptake in saline soils was attributed to precipitation of H_2PO_4 with Ca^{2+} ions in soil and of K and Ca to a competition with Na (Marschner, 1995). The reduction of K percentage could be explained through the competition exists between Na^+ and K^+ leading to a reduced level of internal K^+ at high external NaCl concentration (Botella et al., 1997). Increasing Na and Cl absorption under salinity in this study is agreeing with Turan et al. (2007). Moreover, the accumulation of NaCl disturbed the homeostasis not only Na^+ and Cl^- but also of essential cations such as K^+ and Ca^{2+} (Roussos et al., 2007) and hence a decrease in K^+ and Ca^{2+} in rose leaves was observed. In a recent study of Caia et al. (2014) they concluded that salinity treatment enhances the accumulation of leaf Na^+ and Cl^- ions, thereby reducing plant growth rate and hence minimizing the ion uptake by the roots and ion accumulation in the shoots are important mechanisms of salt tolerance.

Data obtained in this study showed that treatment with GA_3 had beneficial effects on vegetative growth as well as

physiological and chemical parameters investigated. Moreover, the negative effects of salinity concerning ion homeostasis in rose under saline conditions were alleviated. The vegetative growth promotion of rose plants by GA₃ treatment could be explained through the role of GA₃ in leaf expansion and stem elongation (Magome et al., 2004). The reduction in plant growth at different salinity levels was occurred without GA₃ treatment, while under GA₃ treatments the growth characters were enhanced. These results are in agreement with Misratia et al. (2013) who mentioned that GA₃ in salt stressed plants showed an increased photosynthetic capacity a vital factor for higher dry matter synthesis. Improving leaf area, chlorophyll content and TSS by GA₃ treatment may be achieved through osmoregulation which in turn increased RWC using the organic solutes (saccharides and proteins), which in turn increased the photosynthetic area of rose plant. Otherwise, applying GA₃ under salinity treatment was found to restore normal chlorophyll levels (Shaddad et al., 2013).

Salinity alleviation by GA₃ may occur through its effect on proline metabolism via regulating N or Ca accumulation (Iqbal et al., 2014) as our data indicated. Positive interactions between GA₃ and proline have been reported in the literature. Tuna et al. (2008) reported that foliar application of GA₃ increased proline content which counteracted some of the adverse effects of salinity by maintaining membrane permeability and increasing macro and micronutrient levels. This enhanced accumulation of proline may represent a major biochemical adaptation in plants osmotic adjustment (Khan et al., 2010). GA₃ also increased the antioxidant enzyme activities which may consider as a mechanism for salinity alleviation. GA₃ that primarily affect cell enlargement and growth must also coordinately interact with ABA under stress and possibly other stress metabolites, including antioxidants and ROS scavengers (Achar et al., 2006). Foliar application of GA₃ led to increase of Ca²⁺ concentration and induce maintenance of K⁺, hence altered ion homeostasis as the obtained data showed. GA₃ may increase Ca²⁺ by increasing the influx of Ca²⁺ at the plasma membrane (Gilroy and Jones, 1992). Similar trend has been reported (Iqbal and Ashraf, 2010). Several reports have indicated that GA₃ application on crops produced some benefit in alleviating the adverse effects of salt stress (Chakrabarti and Mukherji, 2004).

As a conclusion, salinity treatments negatively affected the growth of rose plants. Under salinity treatments RWC, chlorophyll and leaf area were decreased. However, stomatal density, TSS, proline, membrane permeability and antioxidant enzyme activities were increased. On the other hand, GA₃ treatments alleviated the negative effects of salinity on the growth and physiological and biochemical parameters previously mentioned. GA₃ treatment increased proline content and antioxidant enzymes activities (SOD, CAT and POD) as well as prevented ion homeostasis which may consider possible mechanisms for salinity tolerance in rose.

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